I CLAIM:

1. A gas separation system for separating a feed gas mixture comprising a first gas component and a second gas component, the gas separation system comprising:

a stator, including a first stator valve surface, a second stator valve surface; and a plurality of function compartments opening into the stator valve surfaces;

a rotor rotatably coupled to the stator, and including a first rotor valve surface in communication with the first stator valve surface, a second rotor valve surface in communication with the second stator valve surface, and a plurality of rotor flow paths for receiving adsorbent material therein for preferentially adsorbing the first gas component in response to increasing pressure in the rotor flow paths in comparison to the second gas component, each said rotor flow path including a pair of opposite ends opening into the rotor valve surfaces for communication with the function compartments; and

centrifugal turbomachinery coupled to a portion of the function compartments, and including an impeller having a plurality of impeller flow paths for exposing each said rotor flow path to a plurality of different pressures between an upper pressure and a lower pressure as the rotor rotates for separating the first gas component from the second gas component.

2. The gas separation system according to claim 1, wherein each said impeller flow path communicates with a respective one of the function compartments for maintaining each said function compartments at one of the plurality of pressures.

3. The gas separation system according to claim 1, wherein the centrifugal turbomachinery comprises a split stream centrifugal compressor for delivering the feed gas mixture to the first stator valve surface at a plurality of different feed gas pressure levels.

4. The gas separation system according to claim 1, wherein the centrifugal turbomachinery comprises a split stream centrifugal expander for exhausting gas flows enriched in the first gas component received from the first stator valve surface at a plurality of different exhaust gas pressure levels as a first product gas.

5. The gas separation system according to claim 3, wherein the centrifugal turbomachinery comprises a split stream centrifugal expander coupled to the centrifugal compressor for exhausting gas

enriched in the first gas component received at a plurality of different exhaust gas pressure levels from the first stator valve surface as a first product gas and for assisting the centrifugal compressor in delivering the feed gas mixture to the first stator valve surface.

6. The gas separation system according to claim 1, wherein the centrifugal turbomachinery comprises a split stream centrifugal expander for extracting gas enriched in the first gas component received from the first stator valve surface at a plurality of different exhaust gas pressure levels as a first product gas.

7. The gas separation system according to claim 3, wherein the centrifugal turbomachinery comprises a split stream centrifugal vacuum pump coupled to the centrifugal compressor for extracting gas enriched in the first gas component received from the first stator valve surface at a plurality of different exhaust gas pressure levels as a first product gas and for assisting the centrifugal compressor in delivering the feed gas mixture to the first stator valve surface.

8. The gas separation system according to claim 1, wherein the gas separation system includes a light reflux expander for receiving gas enriched in the second gas component from the second stator valve surface at a plurality of different reflux exit gas pressure levels, for performing pressure let-down of the received gas, and for returning the pressure-reduced received gas as light reflux return gas to the second stator valve surface to enhance purity of gas extracted from the second stator valve surface enriched in the second gas component as a second product gas.

9. The gas separation system according to claim 8, wherein the gas separation system includes a compressor coupled to the light reflux expander for increasing a pressure of the gas extracted as the second product gas.

10. The gas separation system according to claim 1, wherein the gas separation system includes at least one throttle valve for receiving gas enriched in the second gas component from the second stator valve surface at a plurality of different reflux exit gas pressure levels, for performing pressure let-down of the received gas, and for returning the pressure-reduced received gas as light reflux return gas to the second stator valve surface to enhance purity of gas extracted from the second stator valve surface enriched in the second gas component as a second product gas.

11. The gas separation system according to claim 3, wherein the split stream centrifugal compressor comprises a gas inlet for receiving the feed gas mixture, a plurality of blades extending radially outwards from the impeller, a channel disposed within the impeller in communication with the gas inlet and extending between adjacent pairs of the blades, the blades including a plurality of steps positioned at differing radial distances from an axis of rotation of the impeller, the steps defining the impeller flow paths for ejecting the feed gas mixture from the channel at a plurality of different angular momentums; and a plurality of diffusers in communication with the channel for providing the different feed gas pressure levels of the feed gas mixture.

12. The gas separation system according to claim 11, wherein at least one of the diffusers comprises a diffuser inlet for receiving a portion of the ejected feed gas mixture, a plurality of diffuser outlets, and a plurality of diffuser flow paths extending between the diffuser inlet and the diffuser outlets for providing the different feed gas pressure levels.

13. The gas separation system according to claim 12, wherein the diffuser flow paths comprise a primary diffuser channel opening into one of the diffuser outlets, a secondary channel opening into another of the diffuser outlets, and an aperture provided in the primary diffuser channel for diverting a boundary gas flow layer from the primary channel into the secondary channel so as to deliver gas from the secondary channel at a reduced pressure from the primary channel.

14. The gas separation system according to claim 3, wherein the split stream centrifugal compressor comprises a gas inlet for receiving the feed gas mixture, a plurality of blades extending radially outwards from the impeller, a channel disposed within the impeller in communication with the gas inlet and extending between adjacent pairs of the blades, the blades having respective blade angles defining the impeller flow paths for ejecting gas flows of the feed gas mixture from the channel at a plurality of different angular momentums; and a plurality of diffusers in communication with the channel for providing the different feed gas pressure levels of the feed gas mixture.

15. The gas separation system according to claim 14, wherein the blades each have a height, and the respective blade angle changes over the respective blade height.

16. The gas separation system according to claim 14, wherein the channel includes a plurality of compartments for maintaining separation of the feed gas mixture flows through the channel.

17. The gas separation system according to claim 14, wherein at least one of the diffusers comprises a diffuser inlet for receiving a portion of the ejected feed gas mixture, a plurality of diffuser outlets, and a plurality of diffuser flow paths extending between the diffuser inlet and the diffuser outlets for providing the different feed gas pressure levels.

18. The gas separation system according to claim 17, wherein the diffuser flow paths comprise a primary diffuser channel opening into one of the diffuser outlets, a secondary channel opening into another of the diffuser outlets, and an aperture provided in the primary diffuser channel for diverting a boundary gas flow layer from the primary channel into the secondary channel so as to deliver gas from the secondary channel at a reduced pressure from the primary channel.

19. The gas separation system according to claim 4, wherein the split stream centrifugal expander comprises a gas outlet for exhausting the first product gas, a plurality of blades extending radially outwards from the impeller, a channel disposed within the impeller in communication with the gas outlet and extending between adjacent pairs of the blades, and a plurality of diffusers for delivering the gas flows enriched in the first gas component to the channel at a plurality of different angular momentums, the blades including a plurality of steps positioned at differing radial distances from an axis of rotation of the impeller, the steps defining the impeller flow paths for producing the first product gas from the delivered gas flows.

20. The gas separation system according to claim 4, wherein the split stream centrifugal expander comprises a gas outlet for exhausting the first product gas, a plurality of blades extending radially outwards from the impeller, a channel disposed within the impeller in communication with the gas outlet and extending between adjacent pairs of the blades, and a plurality of diffusers for delivering the gas flows enriched in the first gas component to the channel at a plurality of different angular momentums, the blades having respective blade angles defining the impeller flow paths for producing the first product gas from the delivered gas flows.

21. The gas separation system according to claim 20, wherein the blades each have a height, and the respective blade angle changes over the respective blade height.

22. The gas separation system according to claim 20, wherein the channel includes a plurality of compartments for maintaining separation of the delivered gas mixtures through the channel.

23. The gas separation system according to claim 6, wherein the split stream centrifugal vacuum pump comprises a plurality of gas inlets for receiving gas flows of the gas enriched in the first gas component at the plurality of different exhaust gas pressure levels, a plurality of blades extending radially outwards from the impeller, a channel disposed within the impeller in communication with the gas inlets and extending between adjacent pairs of the blades, the blades having respective blade angles defining the impeller flow paths for ejecting the flows of the gas enriched in the first gas component from the channel at a common angular momentum; and a diffuser in communication with the channel for producing the first product gas from the ejected gas flows.

24. The gas separation system according to claim 23, wherein the blades each have a height, and the respective blade angle changes over the respective blade height.

25. The gas separation system according to claim 23, wherein at least one of the gas inlets includes swirl means for delivering the received gas flows to the channel with a swirl velocity.

26. The gas separation system according to claim 25, wherein the swirl means includes at least one of guide vanes, nozzles and volutes.

27. The gas separation system according to claim 23, wherein the channel includes a plurality of compartments for maintaining separation of the gas flows through the channel.

28. The gas separation system according to claim 6, wherein the split stream centrifugal vacuum pump comprises a plurality of gas inlets for receiving flows of the gas enriched in the first gas component at the plurality of different exhaust gas pressure levels, a plurality of blades extending radially outwards from the impeller, a channel disposed within the impeller in communication with the gas inlets and extending between adjacent pairs of the blades, the blades including a plurality of steps positioned at differing radial distances from an axis of rotation of the impeller, the steps defining the impeller flow paths for ejecting the flows of the gas enriched in the first gas component from the channel at a common angular momentum; and a diffuser in communication with the channel for producing the first product gas from the ejected gas flows.

29. The gas separation system according to claim 28, wherein at least one of the gas inlets includes swirl means for delivering the received gas flows to the channel with a swirl velocity.

30. The gas separation system according to claim 29, wherein the swirl means includes at least one of guide vanes, nozzles and volutes.

31. The gas separation system according to claim 8, wherein the light reflux expander comprises a plurality of blades extending radially outwards from the impeller, a channel disposed within the impeller extending between adjacent pairs of the blades, a plurality of gas inlets for directing flows of the gas enriched in the second gas component at the plurality of light reflux exit pressure levels to the channel, the channel including a plurality of steps positioned at differing radial distances from an axis of rotation of the impeller, the steps defining the impeller flow paths for ejecting the gas flows from the channel at a plurality of angular momentums, and a plurality of diffusers in communication with the channel for delivering each said ejected gas flow at a pressure level less than the respective light reflux exit pressure level.

32. The gas separation system according to claim 31, wherein the blades have blade angles, and the angular momentums are defined in accordance with the blade angles.

33. The gas separation system according to claim 31, wherein the channel includes an inlet end and an outlet end, and the steps are positioned at both said ends.

34. The gas separation system according to claim 31, wherein the channel includes a plurality of compartments for maintaining separation of the gas flows.

35. The gas separation system according to claim 1, wherein the impeller comprises a double-sided impeller, and the centrifugal turbomachinery includes a plurality of blades extending radially outwards from the impeller, a first gas inlet volute and a first gas outlet diffuser communicating with a first side of the impeller, a second gas inlet volute and a second gas outlet diffuser communicating with a second side of the impeller, a first channel disposed within the first side of the impeller communicating with the first gas inlet volute and the first gas outlet diffuser, and a second channel disposed within the second side of the impeller and communicating with the second gas inlet volute and the second gas outlet diffuser, the first and second channels each extending between adjacent pairs of the blades.

36. The gas separation system according to claim 35, wherein the impeller has an axis of rotation, and the first and second sides are disposed on opposite sides of the axis of rotation.

37. The gas separation system according to claim 35, wherein the blades include a plurality of steps positioned at differing radial distances from an axis of rotation of the impeller, the steps defining the impeller flow paths for ejecting gas flows from at least one of the channels at a plurality of different angular momentums.

38. The gas separation system according to claim 35, wherein the blades have respective blade angles defining the impeller flow paths for ejecting gas flows from at least one of the channels at a plurality of different angular momentums.

39. The gas separation system according to claim 35, wherein the centrifugal turbomachinery is configured as a split stream compressor for receiving feed gas at the inlet volutes at a common feed gas inlet pressure level and for delivering the received feed gas from the outlet diffusers to the first stator valve surface at a plurality of different feed gas pressure levels.

40. The gas separation system according to claim 35, wherein the centrifugal turbomachinery is configured as a split stream vacuum pump for receiving gas enriched in the first gas component at the inlet volutes at a plurality of different exhaust gas pressure levels and for ejecting the received gas as a first product gas from the outlet diffusers at a common first product gas pressure level.

41. The gas separation system according to claim 35, wherein the centrifugal turbomachinery is configured as a split stream centrifugal expander for receiving gas flows enriched in the second gas component at the inlet volutes at a plurality of different light reflux exit pressure levels and for discharging each said received gas flow at a pressure level less than the respective light reflux exit pressure level.

42. The gas separation system according to claim 35, wherein the centrifugal turbomachinery is configured as a split stream centrifugal expander for receiving gas flows enriched in the first gas component at the inlet volutes at a plurality of different exhaust pressure levels and for exhausting the received gas as a first product gas from the outlet diffusers at a common first product gas pressure level.

43. The gas separation system according to claim 1, wherein the impeller comprises a twin impeller comprising a first impeller portion and a second impeller portion coaxial and coupled to the first impeller portion, and the centrifugal turbomachinery includes a plurality of blades extending radially outwards

from the impeller, a first gas inlet volute and a plurality of first gas outlet diffusers communicating with the first impeller portion, a plurality of second gas inlet volutes and a second gas outlet diffuser communicating with the impeller portion, a first channel disposed within the first impeller portion communicating with the first inlet volute and the first outlet diffusers, and a second channel disposed within the second impeller portion and communicating with the second inlet volutes and the second outlet diffuser, the first and second channels each extending between adjacent pairs of the blades.

44. The gas separation system according to claim 43, wherein the first impeller portion, the first inlet volute and the first outlet diffusers are configured together as a split stream centrifugal compressor for receiving feed gas at the first inlet volute and for delivering the received feed gas from the first outlet diffusers to the first stator valve surface at a plurality of different feed gas pressure levels, and the second impeller portion, the second inlet volutes and the second outlet diffuser are configured together as a split-stream expander for receiving gas flows enriched in the first gas component at the second inlet volutes at a plurality of different exhaust pressure levels and for exhausting the received gas flows as a first product gas from the outlet diffuser at a first product gas pressure level.

45. The gas separation system according to claim 43, wherein the first impeller portion, the first inlet volute and the first outlet diffusers are configured together as a split stream centrifugal compressor for receiving feed gas at the first inlet volute and for delivering the received feed gas from the first outlet diffusers to the first stator valve surface at a plurality of different feed gas pressure levels, and the second impeller portion, the second inlet volutes and the second outlet diffuser are configured together as a split-stream vacuum pump for receiving gas flows enriched in the first gas component at the second inlet volutes at a plurality of different exhaust pressure levels and for ejecting the received gas flows as a first product gas from the outlet diffuser at a first product gas pressure level.

46. The gas separation system according to claim 1, wherein the centrifugal turbomachinery includes a gas mixing nozzle for mixing blowdown gas flows from at least two of the function compartments, the blowdown gas flows being at different pressure levels.

47. The gas separation system according to claim 46, wherein the mixing nozzle comprises a nozzle housing, the impeller being rotatably disposed with the housing, the nozzle housing and the impeller defining an annular chamber therebetween, and at least two gas inlets coupled to respective ones of the function compartments for directing the blowdown gas flows tangentially into the annular chamber for

mixing therein, the gas inlets receiving the blowdown gas flow at respective ones of the different pressure levels.

48. The gas separation system according to claim 46, wherein the mixing nozzle comprises at least two gas inlets for receiving the blowdown gas flows from respective ones of the function compartments, and a gas mixing section in communication with the gas inlets for combining together the received blowdown gas flows.

49. The gas separation system according to claim 1, wherein the centrifugal turbomachinery includes a diffuser comprising a primary channel for delivering a gas flow to one of the function compartments, and a secondary channel in communication with the primary channel for bleeding off a lower energy boundary gas layer from the delivered gas flow.

50. A centrifugal compression machine comprising:

a double-sided impeller;

a plurality of blades extending radially outwards from the impeller;

a first gas inlet and a first gas outlet communicating with a first side of the impeller;

a second gas inlet and a second gas outlet communicating with a second side of the impeller;

a first channel disposed within the first side of the impeller for passing gas between the first gas inlet and the first gas outlet; and

a second channel disposed within the second side of the impeller for passing gas between the second gas inlet and the second gas outlet, the first and second channels each extending between adjacent pairs of the blades.

51. The centrifugal compression machine according to claim 50, wherein the impeller has an axis of rotation, and the first and second sides are disposed on opposite sides of the axis of rotation.

52. The centrifugal compression machine according to claim 50, wherein the blades include a plurality of steps positioned at differing radial distances from an axis of rotation of the impeller, the steps defining impeller flow paths for ejecting gas flows from at least one of the channels at a plurality of different angular momentums, the gas outlet comprising a plurality of diffusers for ejecting the gas flows at a plurality of different pressure levels.

53. The centrifugalcompressionmachine according to claim 50, wherein the blades have respective blade angles defining the impeller flow paths for ejecting gas flows from at least one of the channels at a plurality of different angularmomentums,the gasoutletcomprising a plurality of diffusers for ejecting the gas flows at a plurality of different pressure levels.

54. The centrifugal compression machine according to claim 50, wherein the blades include a plurality of steps positioned at differing radial distances from an axis of rotation of the impeller, the gas inlet comprising a plurality of volutes for receiving gas flows at a plurality of different pressure levels and for delivering the received gas flows to at least one of the channels at a plurality of different angular momentums, the steps defining impeller flow paths for ejecting the delivered gas flows at a common pressure level.

55. The centrifugal compression machine according to claim 50, wherein the gas inlet comprising a plurality of volutes for receiving gas flows at a plurality of different pressure levels and for delivering the received gas flows to at least one of the channels at a plurality of different angular momentums, the blades having respective blade angles defining impeller flow paths for ejecting the delivered gas flows at a common pressure level.

56. A gas mixing nozzle for combining gas flows at a plurality of different pressures, the mixing nozzle comprising:

a nozzle housing;

an impeller rotatably disposed within the nozzle housing, the nozzle housing and the impeller defining an annular chamber therebetween; and

a plurality of gas inlets provided in the nozzle housing for directing the gas flows tangentially into the annular chamber for mixing therein, each said gas inlet receiving gas at a respective one of the different pressures.

57. The mixing nozzle according to claim 56, wherein the impeller comprises a plurality of blades extending radially outwards therefrom, and a channel disposed within the impeller in communication with the gas inlets and extending between adjacent pairs of the blades, the blades including a plurality of steps positioned at differingradial distances from an axis of rotation of the impeller, the steps defining impeller flow paths for ejecting the gas flows from the channel at a plurality of different angular momentums.

58. The mixing nozzle according to claim 56, wherein the impeller comprises:

a plurality of blades extending radially outwards therefrom; and

a channel disposed within the impeller in communication with the gas inlets and extending between adjacent pairs of the blades, the blades having respective blade angles defining impeller flow paths for ejecting the gas flows from the channel at a plurality of different angular momentums.

59. The mixing nozzle according to claim 56, wherein the gas inlets are disposed at equal angular intervals around the annular chamber.

60. The mixing nozzle according to claim 56, wherein the impeller has an axis of rotation, and the gas inlets comprise pairs of inlet nozzles disposed on opposite sides of the axis of rotation.